

United States Continuation Patent Application for:

**HIGH THROUGHPUT THIN FILM DEPOSITION
AND SUBSTRATE HANDLING METHOD AND
APPARATUS FOR OPTICAL DISK PROCESSING**

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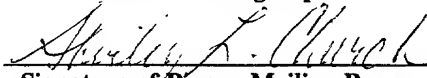
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1 **HIGH THROUGHPUT THIN FILM DEPOSITION AND SUBSTRATE HANDLING**
2 **METHOD AND APPARATUS FOR OPTICAL DISK PROCESSING**
3

4 This application claims the benefit of U.S. Provisional Application No.
5 60/144,602, filed July 19, 1999.

6 **BACKGROUND OF THE INVENTION**

7 1. **Field of the Invention**

8 The present invention relates to a method and apparatus for high throughput
9 thin film deposition upon and substrate handling of optical disk substrates. In
10 particular, multi-layer thin films are deposited on substrates which are subsequently
11 finished for use in optical disk applications such as DVD (digital versatile disk). To
12 obtain increased processing efficiencies, the deposition apparatus includes a moving
13 web which holds substrates in position as they are carried from one processing
14 location to another.

15 2. **Brief Description of Background Art**

16 Throughput or processing rate (number of substrates processed per hour)
17 directly impacts on the cost of manufacturing the optical disks. Due to the nature of
18 the process steps used to produce an optical disk, and particularly thin film deposition
19 where vacuum maintenance requirements and cleanliness (avoidance of substrate
20 contamination by particulates) is critical in ensuring film quality, the optical disk
21 industry has struggled with system-related throughput problems.

22 One of the more popular methods of optical disk production used to improve
23 throughput is the cluster tool. The cluster tool is a multi-chamber tool sharing a
24 common substrate handler. From a cost perspective, multiple chambers running the
25 same process in parallel and sharing a common substrate handler can provide
26 throughput which is superior to an equivalent number of stand-alone single substrate
27 tools or to an in-line system (which will be described subsequently herein). A multi-
28 chamber tool uses floor space and processing time more efficiently than a number of
29 stand-alone single substrate tools. The substrate handler also has much less idle time

1 than if it were only servicing one chamber. While one chamber is busy, the handler
2 can still transfer wafers to or from other pods of the multi-chamber system.

3 Additional economic benefits accrue when a series of processes that could be
4 performed separately are linked in one tool. The reduced substrate handling and
5 decreased numbers of pump-and-vent cycles decrease foreign material, especially in
6 vacuum-equipped clusters used for plasma processing. Eliminating substrate transfer
7 from tool to tool reduces the substrate processing time through the cluster and
8 decreases the cycle time and lot turn-around time. When substrates are processed in a
9 continuous manner, delay times between sequential steps can be more tightly
10 controlled. Clusters that keep substrates under vacuum during diverse sequential
11 process steps allow new processing options since surface interactions with atmosphere
12 and moisture are avoided. Multiple repetitive steps are also more attractive. Despite
13 these advantages, the types and capabilities of the component process
14 modules/chambers and substrate transfer capabilities limit the flexibility of the cluster
15 tools on the market. One of the most significant detractors to cluster processing is
16 mean time-to-failure (MTTF); this must be addressed with high priority, especially
17 since an entire cluster is incapacitated when a single module fails.

18 The overall control of the multi-layer processing may be the most difficult
19 aspect of the cluster system. Due to an intrinsic nature of substrate routing sequence
20 in a cluster tool system, the presently available software limits the maximum
21 throughput. The most popular cluster tool's throughput is limited to about 72
22 substrates per hour for a single-layer deposition. When three different layers must be
23 processes, the presently available throughput is 36 to 40 substrates per hour in a 3-
24 chamber/module system.

25 The production system most commonly used in the industry employs an in-
26 line batch system for the thin film deposition process. In in-line batch systems, the
27 substrates are loaded onto a substrate holder or pallet. In a batch sputter-down
28 system, the substrates may only be placed on a holder. Under this configuration, there

are defects generated from the sputter target and shield areas, which affect on film quality and consequently product yield. Use of pallets also increases the particle occurrence and overall cost of ownership (COO) from maintenance and spare stocks.

An in-line batch system may be able to handle up to about 100 substrates per hour for a single layer film deposition; however, because of batch-nature of the substrate loading, there is a penalty for throughput loss from engineering reliability such as loading and unloading steps. In addition, there is a build up of particulates on the moving carrier used to move the substrates through the deposition processing area. For example, a moving belt which repeatedly circles within the process area, handling a series of substrates, accumulates particulates and requires a cleaning process for particulate removal, leading to high maintenance downtime. In addition to maintenance downtime, particulates which accumulate on the belt may contaminate substrates which contact the belt. Belt hardening occurs over time, requiring belt replacement. When a more complicated product is produced, such as one which requires a three layer film deposition, the slowest deposition process dictates the overall throughput rate for the system, since such systems are not equipped with flexible hardware of the kind which will be described with reference to applicant's invention. In addition, presently known in-line batch systems frequently experience cross-contamination when more than one film material is deposited, due to lack of proper isolation shields between material deposition areas.

Web deposition systems have long been used in the preparation of coated substrates such as metallized films. As its name implies, web deposition or coating involves the vacuum deposition of thin films onto flexible substrates such as films which act as moving webs. The substrate is unrolled from a feed reel at the beginning of the web, the deposition is made on the substrate surface, and then the substrate is rolled back up again on a take up reel. The deposition rate and the film thickness required limit the speed at which the substrate travels past a deposition station. Web

1 coaters often contain several deposition stations that coat the substrate sequentially as
2 it moves past them.

3 Vacuum web coating is the expansion of vacuum coating to large-surface,
4 web-shaped substrates. The substrate is coated in a partial vacuum as the substrate
5 passes by the deposition source along the path between the feed reel and the take up
6 reel. An interesting history of web coating is provided in an article by E.O. Dietrich
7 et al., entitled "Vacuum Web Coating - An Old Technology With A High Potential
8 For The Future", Society of Vacuum Coaters, 40th Annual Technical Conference
9 Proceedings, pp. 354 - 364 (1997). These systems involve the application of coatings
10 to a substrate which is moved past the coating source in the form of a continuous web
11 which is unwound from one roll and rewound upon another roll.

12 In addition to sputter or evaporated coatings, plasma assisted chemical vapor
13 deposition films have been deposited upon moving web substrates. Web coaters may
14 contain several deposition stations that coat the substrate sequentially as it moves past
15 them. Some of the more significant problem areas include the release of water vapor
16 from the substrate during web coating; buckling or tensioning along the longitudinal
17 edges of the web; transverse warping of the web of substrate material; and the
18 presence of particulate contaminants. Transverse warping of the web is caused by the
19 force of gravity acting upon the web, the elongated path of travel which the web of
20 substrate material follows, stresses from external sources developed upon the web of
21 substrate material, the high deposition temperatures to which the web of substrate
22 material is continuously subjected, and the forces created by the highly stressed
23 semiconductor alloy material deposited upon the web of substrate material. U.S.
24 Patent No. 4,664,951 to Joachim Doehler, issued May 12, 1987 describes a method of
25 providing for corrective lateral movement of a web of substrate material which is
26 adapted to continuously move in a longitudinal direction through a vapor deposition
27 processor.

1 In an article entitled "Erasable Phase-Change Optical Materials, MRS Bulletin,
2 September 1996, pp. 48 - 50, Noboru Yamada describes various materials of the kind
3 which can be used to form an erasable optical disk. The erasability is based on optical
4 memory materials which undergo phase changes affecting optical transmission. In
5 practical systems, a laser beam focused into a diffraction-limited spot is used for
6 recording. This enables the spacial size of one bit of data to be very small (of
7 submicron order) so that the recording density is very high. Amorphous recording
8 marks are formed in crystallized areas along tracks. The mark size is about 0.5 μm .
9 The phase-change optical-memory materials must have proper optical constants; an
10 absorption edge that shifts in the visible or near-infrared wavelength region with
11 phase transitions; a suitable melting point -- the materials must be able to be melted
12 with an available laser power, but must not melt at such a low temperature that self-
13 crystallization occurs; and, there must be a rapid and stable phase-transition process.
14 The number of materials meeting this requirement are limited.

15 The Yamada article describes an example erasable optical disk sample
16 where the substrate is PMMA (polymethyl methacrylate) having deposited on its
17 surface three layers. A first layer of ZnS (dielectric undercoat) a second GE-Sb-Te
18 active layer, and an undefined overcoating layer. After deposition of the three layers
19 on the PMMA substrate, an overlying PMMA substrate layer is applied using a
20 photopolymer adhesive. The Yamada article does not describe the apparatus used to
21 fabricate the erasable optical disk; however, it is readily apparent to one skilled in the
22 art that stresses introduced into the depositing materials are likely to have an effect on
23 crystallization and phase-transition processes. With this in mind, it would be highly
24 desirable to have a high throughput apparatus which does not introduce stress into the
25 substrate material or into the thin films being deposited on that material.